MODIS SCIENCE TEAM MEMBER
Semi-Annual Report (July 1995 - December 1995)

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a) Task Objectives

The objectives of this phase of the project were: to continue the research program developing the 'at-launch' algorithms for MODIS atmospheric correction, vegetation indices, fire detection and land cover and to build the infrastructure and collaboration to permit the research to be undertaken. The completion of the ATBD revisions and the development of the beta code were given a high priority. The project has developed a number of collaborative projects which are intended to expand the scope of the team members activities and involve a larger community in the MODIS research. Due to the small number of researchers addressing the issues necessary for the methodological advances needed for MODIS, emphasis has been given to developing collaborative research and MODIS outreach through the IGBP Data and Information System Core Project. In addition, the goals of the MODIS project, the status of the instrument and preliminary results of the research were presented at key scientific meetings. The project was also represented at the MODIS Team meeting. Results of the studies undertaken as part of the project are in the process of being written up and submitted for publication.

b) Tasks Accomplished (Data analysis and interpretation)

3rd Quarter (July - September 1995)

Specifically the project has addressed the following topics over this three month period:

MODIS Atmospheric Correction:

Since June, we have actively worked on bidirectional reflectance issues as they relate to the MODIS atmospheric correction. We have accounted for an anisotropically reflecting surface in our operational routine by creating lookup tables of the surface-atmosphere coupling terms. For a given land target, the appropriate table elements are determined from the past 16-day MODIS- BRDF product and the current atmospheric optical depth. We are also developing accuracy requirements for bidirectional reflectance as we evaluate the standard BRDF product. To this end, we are comparing the MODIS BRDF models against more complex and computationally expensive models for providing the coupling terms. This work includes extensive collaboration with the BU and Montana MODIS teams. By combining bidirectional reflectance with vegetation indices, we have begun to understand the optimal geometries for the formation of vegetation indices. Results have been provided to the MODIS vegetation index team. We are also considering the effects of scale and surface heterogeneity on the MODIS BRDF products. First, we are analyzing the effects of heterogeneity on the inversion of models which assume homogeneity. Second, we are developing methods to deconvolve the reflectance of subpixel homogeneous components such that the derived reflectances can be used in model inversions. The group worked initially on BRDF inversions from remotely sensed data (AVHRR, MODIS Airborne Simulator). BRDFÕs for Desertic sites using AVHRR were successfully modeled using linear and non-linear models. The same result were been obtained for MAS data exhibiting a strong hot-spot over the Eastern United States during the SCAR-A campaign.

Work continues with the Landsat atmospheric correction code for the LTER project and the correction of adjacency effect up to a radius of 20 pixels have been included. The code now processes a full scene in about 2 hours on a HP-735 Workstation.

MODIS Land Cover (w. Strahler et al.) **:**

Justice attended the IGBP Land Cover meeting in Montana and presented the options being considered for Land Cover MODIS Test Site validation. The relationship between the IGBP 1km project, the associated validation exercise and the MODIS at-launch product was examined. Emphasis is to be placed on developing global prototypes using the proposed MODIS land cover approaches.

MODIS Fire Detection (w. Kaufman)

Chris Justice and Luke Flynn attended the 2nd IGBP-DIS Fire Algorithm Workshop at JRC Ispra. The MODIS algorithm and prototyping were presented. Community consensus was reached on improvements to the existing GSFC Fire Algorithm in the areas of background temperature retrieval and emissivity. Prototyping of these improvements will be undertaken at GSFC, prior to generation of an IGBP global 1 km fire product by JRC. The MODIS algorithm will be developed based on the AVHRR prototyping experience. Emphasis is being placed in three areas of research: refining the at-launch active fire detection algorithm and processing chain, including the total emissions algorithm; developing the flaming and smoldering ratio algorithm (Kaufman and Flynn), and developing the post-launch area burned algorithm (Justice).

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MODIS Vegetation Index:(w. Huete)

Work is proceeding to evaluate the IGBP 1km Vegetation Index product and examine the impact of atmospheric correction on the MODIS V1 compositing process. The refined compositing technique is in preparation for the V1 delivery. AVHRR data are being used to prototype the V1 for MODIS.

c) Data / Analysis / Interpretation

¥ MODIS Beta #3 Delivery:

The group worked on integration of the MODLAND thread with SDST (Beta 3 delivery). Software for level 2 processing (atmospheric correction, fire detection, VIÕs computation) was delivered on August 15Th. The code processes the LEVEL 1B MODIS Simulated Data Set and produces MOD09,13,14 in HDF format.

The group continued to work on integration of the MODLAND thread with SDST (Beta 3 delivery). Software for level 2G, 3 processing (atmospheric correction, fire detection, VI's computation). Code for Level 2G and Level 3 was delivered Mid-September. Level 2 now includes an interface with the BRDF product for Atmosphere-BRDF coupling effect correction. The beta 3 codes for level 2 and level 3 surface reflectance, vegetation index and fire were delivered to SDST along with the necessary test datasets (TM data, MAS data and synthetic data). The team also assisted SDST in evaluating the utility of the SDP Toolkit for this particular processing string. The utility of the SDST MAPI was also evaluated. A report was given at the SDST SAP meeting.

The Level 2G gridding code was proposed and developed and tested in collaboration with Robert Wolfe SDST. A preliminary version was delivered as part of the Beta delivery.

Continued analyses of AVHRR, MAS and Landsat TM data were performed as part of the MODLAND prototyping effort

Work continues on establishing ATM Network connectivity between the project SCF and the EDC LAND DAAC. Trial transmission using the ATM is planned for early December. Four ten day periods of 1km data (stitched orbits) will be sent as part of the first phase. Video conference capabilities using the ATM are also being evaluated.

d) Meetings

Justice and Vermote attended the SDST Review (July 17-19). Emphasis was placed on developing the lessons learned from the early stages of the Beta 3 delivery.
Justice (chair) and Vermote attended the SDST Science Advisory Panel Review.
Justice attended the IGBP BAHC Land Cover Meeting in Montana (Sept 5-7)
Justice attended the MODIS session at the MODIS snow/ice workshop (Sept 14)
Justice attended the EOS Airborne Workshop providing input on the MODIS requirements for new airborne sensors (Oct 3-5)
Justice met with SADC Food Security representatives to discuss the feasibility of using MODIS data for near-real time drought monitoring.
Privette presented the current results on the atmosphere/BRDF coupling research at the Europe to Remote Sensing II Meeting in Paris.
Privette attended a one day MODLAND BRDF meeting in Boston.

¥ Upcoming Meetings

Justice has initiated and developed the preliminary agenda and attendees list for the EOS Test Site meeting to be held in January.
The project will be represented at the MODIS team meeting in November.
Vermote will attend the Calibration SAP meeting to be held in January
The MODLAND/SDST meeting on V1 is planned for February.

Papers in Preparation

Wolfe and Vermote - Level 2G Code

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4th Quarter (October - December 1995)

Specifically the project has addressed the following topics over this three month period:

MODIS Atmospheric Correction:

The Beta 3 version of the MODIS software (surface reflectance, VI, fire, Level 2G Toolkit) was consolidated and is now ready for DAAC delivery. As part of the delivery an end-to-end test was conducted on a 16 days composite NDVI product at the SCF. As part of this delivery, the surface reflectance, VI, Fire (level 2 product) were revised.

The 6S Code Version 4..0 has been released on December 15th along with Version 1.0 Manual. The Code interfaces directly with Sun Photometer inversion of particles size distribution. Dr. Vermote worked with the SDST synthetic data team (Kai Yang) to incorporate the 6S code (Vermote et al., 1995) to simulate atmospheric effect on MODIS data in the visible-middle infrared wavelength range.

Work was initiated on the evaluation of DAO surface temperature / water vapor data sets needed as ancillary inputs to MODIS product generation (MODIS ancillary data evaluation).

Atmospheric Correction Validation:

During this performance Dr. Vermote worked on LTER/TM correction software and generated documentation for the code as part of the MODIS prototyping activity. Dr. Vermote started testing the LTER atmospheric correction with 9 scenes acquired for the following LTER sites (Sevilleta, Hog Island,

National Temperature Lake). Corrected / uncorrected scenes are transmitted electronically to LTER-net for evaluation.

MODIS Land Cover:

The PI attended the IGBP Land Cover Algorithm workshop in Montana along with collaborators from the University of Maryland. The workshop laid out a plan for community development of the next generation land cover algorithms.

MODIS Fire Detection:
Justice and Flynn attended the IGBP-DIS Fire Algorithm Workshop at JRC Ispra in October the MODIS algorithm and prototyping activities were presented.

c) Code Development and Data Processing

Louis Giglio prepared the Beta 3 code for Version 1 delivery. This consisted of 1) rewriting portions of the code that needed corrections and/or reorganization to improve clarity and simplify processing, and 2) identifying and optimizing computationally intensive areas.

Rewriting and reorganization was fairly straightforward. A typical improvement was to extract similar, redundant sequences of instructions and rewrite these as a separate, generic function. Additionally, a "wrapper" module was written to interface with most of the SDP (formerly PGS) Toolkit routines that are called, sparing many functions from having to call the Toolkit routines directly. This simplified functions which make SDP Toolkit calls, and eliminated several hundred lines of redundant code. (The Toolkit, which is in principal a good idea, contains many functions that are awkward and/or inconvenient to use, requiring extra "housekeeping" on the part of the programmer.)

Finally, computationally intensive code sections were identified and optimized. Code profiling revealed that the majority of CPU time was spent performing atmospheric correction calculations and evaluating transcendental functions. By optimizing these parts of the code (mainly through the use of different algorithms, rational function approximations, and code restructuring), a 45% reduction in execution time has been achieved. An additional 10% reduction is expected in time for the Version 1 delivery.

d) Meetings Attended

- MODIS Programmer Forum (GSFC) November 14th

- MODIS meeting (GSFC) November 15-17th

- Geography Department /UMD Remote Sensing day (UMD) November 20th

- Meeting on 1km data set evaluation (EDC-DAAC) November 27-28th

- Meeting with SDST synthetic data team (Kai Yang) December 13th

- EOS Airborne Workshop Oct 3-4th

- IGBP Fire Algorithm Workshop, JRC Ispra Oct 17-19.

- IGBP Land Cover Algorithm Workshop, Montana , Sept 5-7th.

Chris Justice also attended the weekly Technical Team Meeting (intermittently) and the Discipline Leaders Meeting (regularly)

e) Obstacles

f) Publications

Accepted Papers

Vermote, E. F., El Saleous, N. Z., Kaufman, Y. J. and Dutton, E. (1995), Stratospheric aerosol perturbing effect on the remote sensing of vegetation: Correction method for the composite NDVI after the Pinatubo eruption, *Accepted in R.S.E.*

Vermote, E. F., Tanre D., Deuze, J. L., Herman, M. and Morcrette, J. J. (1995), Second Simulation of the Satellite Signal in the Solar Spectrum: an overview, *accepted to IEEE Trans. Geosci. Remote Sens.*

Submitted papers

Kaufman, Y. J., Tanre, D., Remer, L., Vermote, E. and Holben, B. (1995), Operational Remote Sensing of Tropospheric Aerosol Over the Land from EOS-MODIS, *Journ. Geophys. Res.* submitted:

In preparation papers

R. Wolfe and E. Vermote - Level 2G Processing

Vermote, E. F., El Saleous, N. Z., Justice, C. O., Kaufman, Y. J., Remer , L., Roger, J. C. and Tanre, D. (1996), Atmospheric correction of visible to middle infrared EOS-MODIS data over land surface, background, operational algorithm and validation, *Journ. of Geophys. Res.* in preparation: